The Standard Model (SM) is the established theory of particle physics down to distance scales as small as a thousandth of a femtometer. The frontier of particle physics is the search for new physics beyond the SM through searches at the Large Hadron Collider (LHC), complimented by high precision measurements of key SM parameters. One such parameter is the mass of the top quark, the heaviest known elementary particle, about 170 times more massive than the hydrogen atom. The uncertainty in its value affects precision fits, limiting the ability to test the SM and constrain new physics. At the LHC, the most precise experimental top mass measurements are based on the method of kinematic reconstruction, which yields enhanced sensitivity to the top quark mass. We perform Monte Carlo simulations of a related observable, the “boosted top jet mass spectrum”, based on a newly developed theoretical framework. We study the sensitivity of this observable to the top quark mass and compare the simulation results to theoretical predictions. We have generated over 18 million simulation events, analyzed them through independently written C++ algorithms, and compared to theoretical predictions. This entire process was automated through a sequence of shell scripts. Good agreement was found with the theoretical predictions. Current work is focused on a detailed statistical analysis of these results for a high precision extraction of the top quark mass.